APPENDIX I

THERMAL TARGET RECOGNITION, IDENTIFICATION, AND ENGAGEMENT

With the nightsight, the Dragon gunner can learn to recognize, identify, and engage targets by their unusual thermal images. On clear nights, he can recognize thermal targets at long ranges.

I-1. TEMPERATURE AND THERMAL IMAGES

An object the same temperature as its background does not show through a nightsight. However, most objects radiate some heat, and even a difference of less than one degree renders an object visible to the gunner using such a sight. Since temperatures generally drop at night, thermal targets show up better through the nightsight then.

a. Some targets, such as tanks and APCs, radiate heat in patterns recognizable to a trained, experienced Dragon gunner.

b. A soldier looking through a nightsight will not see an object of the same temperature as its background. However, the same soldier looking through the same sight will see as bright red any object or area on an object of greater heat than its background, such as engines that have recently been operated. Objects much colder than their backgrounds look black. Objects with less extreme temperatures appear as a less intense red or gray.

I-2. SOURCES OF INFRARED ENERGY

The four sources of infrared energy include the sun, fuel combustion, friction, and radiant heat.

a. **Solar Heat**. Heat from the sun affects only the outside surfaces of objects.

(1) Solar heat highlights the outlines of an object, which helps the gunner recognize targets. For example, a solar-heated M113 APC looks like a box with a sloping front. However, a solar-heated M60A1 tank looks like a small oval on top of a larger oval. Gunners can detect objects at long ranges (out to 2,000 meters), but at medium ranges (800 to 1,200 meters), they can recognize specific shape cues. Profiles are usually easier to recognize than front views.

(2) Not only do atmospheric variables and surface reflections affect the color and intensity of a thermal image, so also does an object's ability to absorb sunlight. For example, dark-colored objects normally absorb sunlight better than light-colored objects.

b. **Fuel Combustion Heat**. An operating engine produces heat that warms up the surface of its surrounding compartment. Engine temperatures can reach up to 200 degrees Fahrenheit.

(1) *Outside Features*. A gunner can seldom clearly see the actual shape of an engine, heated personnel space, muffler, or exhaust pipes, but the transferred heat may reveal features on the surface of the engine compartment.

(2) *Relative Locations*. From the relative locations of what he perceives to be the engine and the exhaust, a trained and experienced gunner can tell whether the vehicle has a front- or rear-mounted engine.

(3) *Directional Movement*. If the vehicle makes evasive maneuvers, the gunner can locate the vehicle's exhaust, which provides an important cue.

c. **Frictional Heat**. Moving parts generate frictional heat, which produces less intense heat than fuel combustion heat. The transport systems of moving vehicles generate frictional heat, which appears as a dim red in the nightsight. Except when high vegetation or dust obscures its transport system, the frictional heat it generates identifies a vehicle as wheeled or tracked.

(1) *Tracked Vehicles*. In a moving tracked vehicle, the tracks, road wheels, drive sprockets, support rollers, and shock absorbers generate heat. When shock absorbers radiate the heat they have absorbed, the gunner can identify them at longer ranges. At short to medium ranges, radiant heat from shock absorbers could help the gunner identify the vehicle.

(2) *Wheeled Vehicles*. In a moving wheeled vehicle, the tires, shock absorbers, differentials, drive shafts, transmissions, and axles generate heat. Gunners can detect the tires, shock absorbers, and differentials of a wheeled vehicle at medium to long range.

d. **Radiant Heat**. Smooth, shiny surfaces, such as windshields and glossy, painted fenders, reflect radiant heat from other sources. These reflections can produce odd images. For example, the fenders of an enemy tank appear black due to this thermal reflection; a glossy, painted vehicle could reflect off the tank's flat surfaces. An overcast sky can cause warmer thermal reflections. Diffuse surface reflections seldom cause problems.

I-3. EFFECTS OF WEATHER AND OBSCURANTS

Variations in solar heat, fuel combustion heat, frictional heat, and thermal reflection affect infrared signatures and target recognition cues. Also, various atmospheric conditions affect the view through the nightsight, for better or worse.

a. **Precipitation**. Infrared energy transmits poorly through falling precipitation such as rain, snow, or fog, even when basic signature cues do not change. Falling rain and snow restrict visibility more than fallen rain and snow. During rain or snow, background objects and target features heated by friction and the sun lose their heat. Water, ice, or mud buildup on the transport system reduces frictional heat. The temperatures of engine compartments and exhausts remain high. Landmarks, such as trees, trails, and contour features, and background objects, such as trees and rocks, cool so much they may no longer be visible. This reduces scene clutter and can increase *target detection* capability. However, *target recognition* lessens as certain target features cool down. Rain and snow cool the target and reduce its contrast, causing a "snowy" image. The gunner adjusts the contrast control on the nightsight to compensate.

b. **Fallen Snow.** Snow reduces the temperatures of targets and background objects. Fallen snow evens out ground temperatures, which renders terrain features invisible. Without terrain features to use as a size reference, depth perception by size comparison becomes difficult.

c. **Dust, Diesel Fog, and Oil Smoke**. Dust particles created by the impact of artillery rounds reduce the nightsight's effectiveness.

I-4. TARGET IDENTIFICATION

Vehicles have distinguishing characteristics or cues by which they can be classified and identified. Changes in atmospheric and ground conditions affect identification. To help compensate for these variables, the gunner must know how to use the control settings on the nightsight.

a. **Contrast and Brightness Controls**. Gunners can set the contrast and brightness (image) controls for the greatest internal detail of the target, then reset them to enhance other target-recognition cues. To increase their understanding of how these cues affect the thermal image and target recognition cues, gunners should experiment with the contrast and brightness controls (Figure I-1).

BRIGHTNESS	CONTRAST	APPLICATION
Low	Medium to high	• Suppresses background clutter. • Use in rainy, dusty, and lightly foggy conditions. • Reveals hot objects only—cool ones will be invisible. • When possible target appears, increase brightness and lower contrast gradually to reveal more thermal detail.
Medium to low	Medium	• Best overall setting for long ranges. • Gradually reduce brightness to reveal cooler parts, such as tracks and road wheels, which will darken before the hotter parts do. • Observe carefully while adjusting from medium to low and back. Gradual changes in brightness reveal distinctive features and aid in determining the hottest ones.

Medium	Medium to high	• Ranges greater than 1,200 meters.
		• Best combination of settings to reveal the hull shapes and overall silhouettes of target vehicles.
		• Especially useful for—
		  – Identifying small target images with few recognizable features.
		  – Tracking long-range targets in poor visibility such as heavy fog or dust.
		  – Searching tree lines in wet conditions. Limitation of this setting: a snowy, distorted, tough-to-interpret image does not enhance target identification.

Figure I-1. Setting combinations for contrast and brightness controls.

b. **Focus Controls**. Most nightsight focus controls are sensitive; that is, a small movement of the control knob causes a large change in focal point. If a gunner has trouble focusing, he should check the image (contrast and brightness) controls.

(1) To adjust the reticle, turn the focus control (located on the eyepiece).

(2) Adjust the range focus lever. Before focusing the objective lens, move the image controls (contrast and brightness) to the low-to-medium level. Gunners learn to focus the objective lens skillfully through trial and error. This presents a challenge, because infrared heat diffuses on objects. It seldom yields the clear, straight lines that other types of sights do. Thus, you must learn to focus by moving the control back and forth to obtain the best image. Start by aiming the nightsight at a prominent object. Once you have determined the best image, you can experiment by focusing on different objects at different ranges.

I-5. BATTLEFIELD IDENTIFICATION

Using a nightsight to identify targets on a battlefield presents a challenge also. In a target-rich environment on a dry, clear night, high-confidence identification requires a thermal image of such features as road wheels, turret shapes, gun tube, and exhaust location. In clear weather, a gunner can thermally distinguish an M60A1 main battle tank from a T-62 medium tank at a range of 800 to 1,200 meters. To identify a target, a gunner should ask himself the following questions:

- Is the target moving? In what direction?
- Where is the engine? Where is the exhaust?
- Is the target in the unit's section? Should it be there?
- Is the target in a formation?
- Is the target firing at friendly or enemy units?

I-6. PRIMARY RECOGNITION CUES

The friendly and enemy cues shown in the following figures help in training gunners to recognize vehicles.

- Figure I-2. M60A1 main battle tank (page I-5).
- Figure I-3. M551 light tank (page I-6).
- Figure I-4. M113 armored personnel carrier (page I-7).
- Figure I-5. Trucks (page I-8).
- Figure I-6. T-62 medium tank (page I-9).
- Figure I-7. BMP infantry combat vehicle (page I-10).
- Figure I-8. BTR-60 armored personnel carrier (page I-11).
- Figure I-9. BRDM-2 reconnaissance vehicle (page I-12).

M60A1 Main Battle Tank

Classification. Main characteristics of the M60A1 main battle tank include—
- A rear engine.
- An oval-shaped track and road wheel pattern.
- An overall hull, turret, and gun pattern that may be visible with the maximum setting.
- A gun tube that can be seen when the gun has recently fired.

Side-View Identification. M60A1 main battle tank characteristics visible from both sides include—
- A rear engine and a rearward exhaust.
- A high-profile track pattern with hot, taut tracks. (The gunner may see the six evenly spaced road wheels and three support rollers, especially at short ranges.)
- A large, centrally mounted turret.
- A medium-length gun tube that can be seen at short ranges. When the gun has recently fired, the gun tube can be seen at long ranges. (The bore evacuator is two-thirds of the way down the length of the barrel.)
- A high overall profile with a large turret mounted in the center.

Front View Identification. M60A1 main battle tank characteristics visible from the front include—
- Two warm tracks, separated by a cool hull. The lower front hull will appear warm if the personnel heater has operated recently.
- A cool front hull, which indicates a rear-engine vehicle.
- One track that seems wider, if the vehicle sits slightly oblique to the viewer.
- A gun tube that observers can see when the gun has recently fired.

Effects of Motion. The M60A1 main battle tank's direction of movement may indicate the location of its engine. Other characteristics that observers could see when the M60A1 main battle tank moves include—
- A transport system that becomes warmer and more visible during movement.
- A slower bounce than a lighter vehicle.
- A sometimes visible exhaust plume, whose direction indicates the direction of movement.

Distinguishing Features. The side view of the M60A1 track pattern appears higher and more uniformly warm than the side view of the T-62. The tracks of the T-62 are cooler toward the front and smaller than those of the M60A1 tank. From the front, the M60A1 main battle tank appears hotter and larger than the T-62 medium tank.
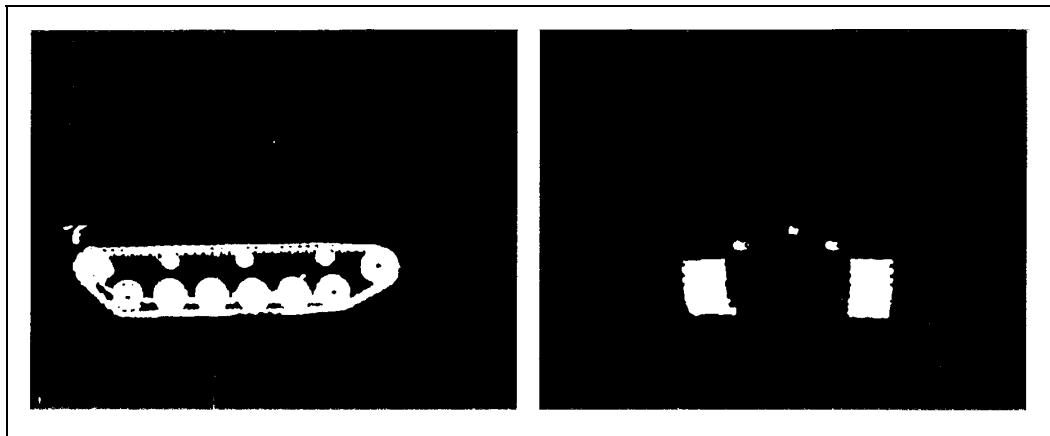

Figure I-2. M60A1 main battle tank.

M551 Light Tank

Classification*.* Main characteristics of the M551 light tank include—
- A rear engine.
- An oval-shaped track and road wheel pattern.
- A combined hull, turret, and gun pattern.

Side-View Identification*.* M551 light tank characteristics visible from both sides include—
- A rear engine and rear exhaust, whose plume may be directed upward or rearward.
- A low profile: low hull and a small, low, flat turret.
- A wedge-like shape, with the wedge pointing to the vehicle's front and visible between 800 and 1,200 meters.
- A high side decking.
- Warm, slack tracks and (at short ranges) five evenly spaced road wheels.
- A short gun tube that can be seen when the gun has recently fired.

Front-View Identification*.* M551 light tank characteristics visible from the front include—
- A wide, low turret, whose sides extend almost over the tracks, providing a unique front view.
- Warm tracks separated by a cool hull, visible as two red spots.

Effects of Motion*.* The M551 light tank's direction of movement may indicate the location of its engine. Other characteristics that observers could see when the M551 light tank moves include—
- A transport system that becomes warmer and more visible during movement.
- A slower bounce than a lighter vehicle.

Distinguishing Features*.* The M551 light tank has a wide, low turret (front view) and a wedge shape (side view). Otherwise, its signatures are difficult to distinguish from those of a T-62 tank.
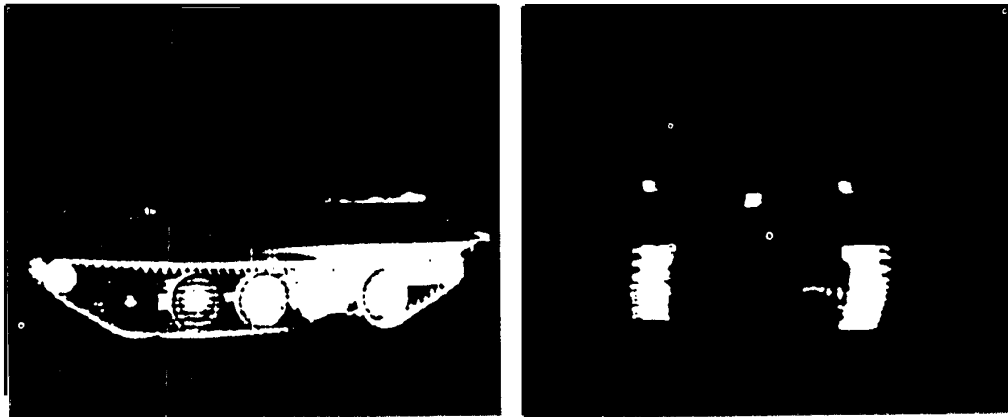

Figure I-3. M551 light tank.

M113 Armored Personnel Carrier

Classification. Main characteristics of the front-engine M113 APC include—
- An oval-shaped track and road wheel pattern.
- A box-shaped hull with no turret.

Side-View Identification. From the right, even at long ranges, you can see the M113 APC's characteristic front hot corner. From the left, you can see a cool box shape. Characteristics visible from both sides include—
- A beveled front end.
- A low track.
- A track skirt, which gives the track a low profile.
- Five evenly spaced road wheels.

Front-View Identification. The M113 APC's characteristic hot spot can be seen on its front right corner. Other characteristics visible from the front include—
- A dark surfboard across the front of the vehicle.
- An overall boxy shape (at the maximum range setting).
- On the front right corner, an upward-moving exhaust plume that can be seen at short ranges.

Effects of Motion. The M113 APC's direction of movement may indicate the location of its engine, which will get hotter and more visible as it operates. Other characteristics that observers could see when the M113 APC moves include—
- A transport system that becomes warmer and more visible during movement.
- A slower bounce than a lighter vehicle, but a faster bounce than a tank.
- A sometimes visible exhaust plume whose direction indicates the direction of movement.
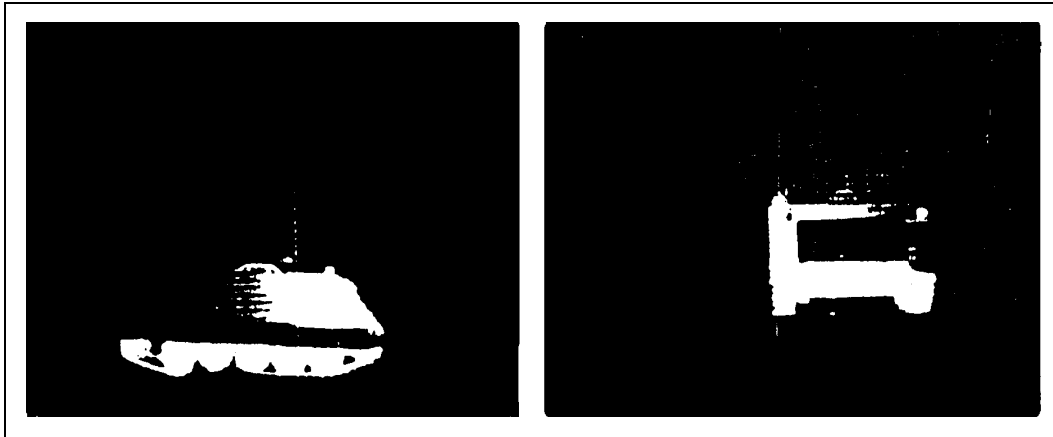

Figure I-4. M113 armored personnel carrier.

Trucks
(All truck cues are combined)

External size cues are needed to establish the size of a truck. To estimate the size of a cue, the gunner compares a nearby tree or other background feature to the size of the red spot. He can also use the reticle to gage size. This is most accurate at low to medium settings.

Side-View Identification. Truck characteristics visible from both sides include—
* A prominent square, also visible from the front, that indicates a front engine. The entire hood and radiator usually appear hot, and the front wheels may seem to merge into the image of the engine.
* Warm spots, separated from the front wheels, that indicate rear wheels. These are easily distinguished from a track pattern.
* Silhouettes of the cab and hood, which may appear at maximum settings. (Long-bed trucks often appear as other truck shapes from the side, even at long ranges.)
* A diagonally-angled drive shaft that is often visible as a bright area joining the engine and rear wheels.
* Exhaust pipes and stacks, which appear hot along their entire length. These appear as different shapes, depending upon how they are routed through the vehicle's frame.

Front-View Identification. Truck characteristics commonly visible from the front include—
* A bright red square or rectangle, indicating the engine compartment, hood, radiator, and, if a personnel heater is in use, the cab. Front views of trucks are all similar at medium and long ranges.
* Wheels and a front axle area that often merge into a continuous red spot beneath the engine. Lower settings improve this image so the gunner can see the vehicle's wheels.
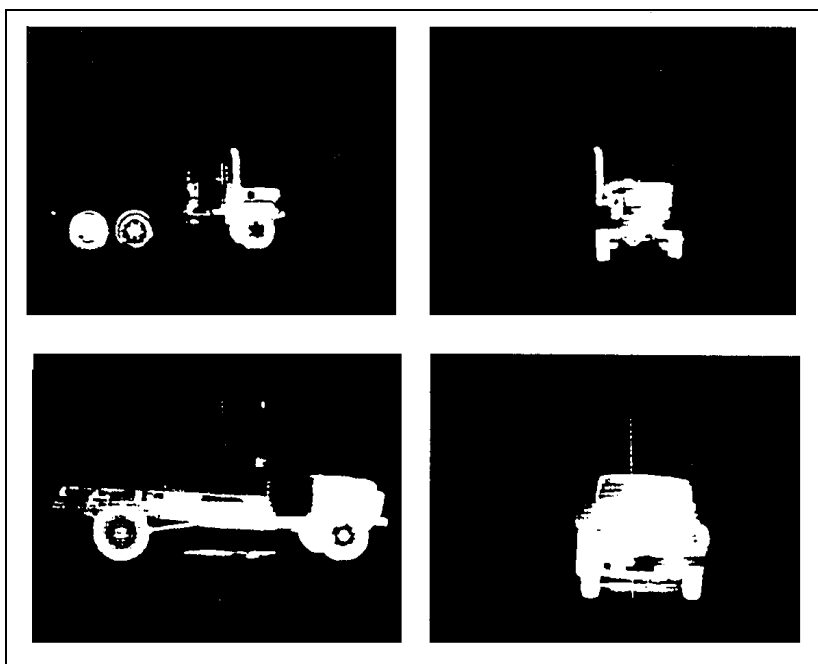* Canvas and wood parts. These parts usually appear cool at night and warm during the day.

Figure I-5. Trucks.

T-62 Medium Tank

Classification. Main characteristics of the T-62 medium tank include—
- A rear engine.
- An oval-shaped track and road wheel pattern.
- A combined hull, turret, and gun pattern that may be visible at maximum range setting.
- A gun tube that can be seen when the gun has recently fired.

Side-View Identification. On the left side of the T-62 medium tank, a large heated area and exhaust flume indicate a rear engine. T-62 medium tank characteristics visible from both sides include—
- Low-profile, slack tracks and, at short ranges, five road wheels with unique (unequal) spacing.
- A low overall profile with a cool hull.
- A long gun tube that can be seen when the gun has recently fired.
- A small, centrally mounted turret.

Front-View Identification. T-62 medium tank characteristics visible from the front include—
- A cool, low overall profile, with a left side that is warmer than the right.
- Warm tracks separated by a cool hull and cool fenders that may appear black above the tracks.
- A small, dome-shaped turret.
- A long gun tube that can be seen when the gun has recently fired. When aimed straight at the viewer, it appears as a red spot. Its firing signature can be seen only at short ranges.

Effects of Motion. The direction of movement may reveal the location of the engine. Other characteristics that observers could see when the T-62 medium tank moves include—
- A transport system that becomes warmer and more visible during movement.
- A slower bounce than a lighter vehicle.
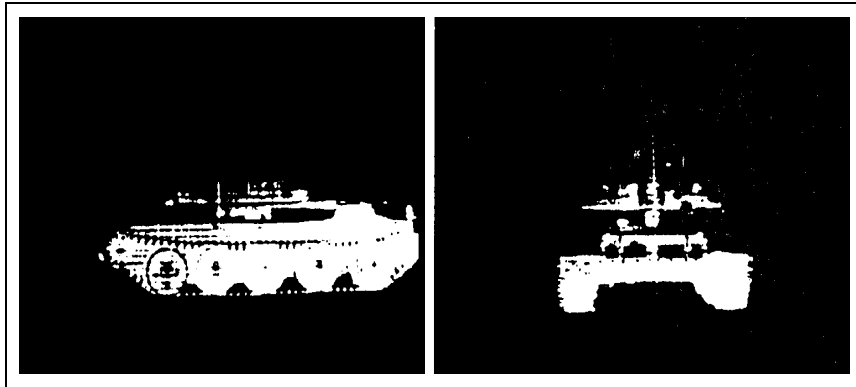- A sometimes visible exhaust plume whose direction indicates the direction of movement.

Figure I-6. T-62 medium tank.

BMP Infantry Combat Vehicle

Classification. Main characteristics of the BMP infantry combat vehicle include—
- An engine mounted in the front right of the vehicle and visible from its front and right.
- A taut track pattern and, at close ranges, visible wheels and support rollers.
- A low overall profile that can be seen at higher settings.
- A gun tube that can be seen when the gun has recently fired.

Side-View Identification. The right side of the BMP infantry combat vehicle is hotter than its left side and is usually more recognizable than other views. The engine appears as a large red spot in the forward half, and the exhaust port is hotter and brighter red than the engine. The tracks and engine area appear together to form a boat-like shape on the right side. BMP characteristics visible from both sides include—
- A track pattern that can be seen at long ranges.
- A forward end that slopes upward from the track to the front fender.
- Cool track fenders that block the view of the upper track.
- A long, low shape that can be seen at high settings.

Front-View Identification. BMP characteristics visible from the front include—
- An engine located in the right front, indicated by a square-shaped red spot.
- A cool, front deck panel, indicated by a black line across the engine's red spot.
- A sometimes visible exhaust plume which vents upward from the right side of the vehicle.
- An exhaust port that can be seen as a small red spot in the top-right corner of the engine's larger red spot.
- Visible tracks, with a small gap separating the red spot of the vehicle's left track from the engine's red spot.
- A turret that cannot be seen at long ranges.

Effects of Motion. The direction of movement may reveal the location of the engine, and changing target views may reveal other features such as—
- A transport system that becomes warmer and more visible during movement.
- A slower bounce than a lighter vehicle.
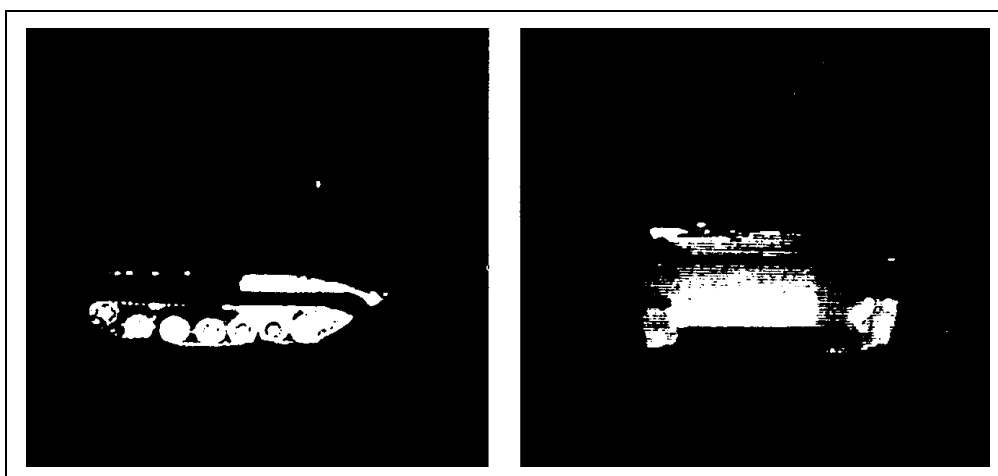- A sometimes visible exhaust plume whose direction may indicate the direction of movement.

Figure I-7. BMP infantry combat vehicle.

BTR-60 Armored Personnel Carrier

Classification. Main characteristics of the BTR-60 include—
- A rear engine and multiple wheels that can be distinguished from the side at long ranges.
- Mufflers on the rear deck that intensify the rear-engine compartment cue.
- A long, high profile, apparent even at long ranges.
- A gun tube that can be seen when the gun has recently fired.

Side-View Identification. BTR-60 characteristics visible from both sides include—
- A rear engine, which creates the brightest spot on the image.
- Four large, inflatable tires on each side, with a gap between the front and rear pairs.
- Two mufflers mounted over the rear engine compartment.
- A small turret that can be seen at medium ranges and that sometimes can be seen at long ranges.
- Identical left-side and right-side views.

Front-View Identification. BTR-60 characteristics visible from the front include—
- A pattern across the front surface, caused by variations in temperature, visible as multiple shapes.
- A rounded hull.
- A cool surfboard that divides the top and bottom halves of the front hull.
- A cool front, unless the personnel heater is in use.
- Shock absorbers that can be seen at medium ranges.

Effects of Motion. The vehicle's direction of movement may indicate the location of its engine, which will get hotter as it operates and thus brighter red. Other characteristics that observers could see when the BTR-60 moves include—
- Its wheels, which will become more visible as they get warmer.
- Its mufflers, which will also become more visible as they get hot.
- A slow bounce, even on rough terrain, which identifies it as a large vehicle.
- A sometimes visible exhaust plume whose direction indicates the direction of movement.

NOTE: Some of the heat from the muffler merges with the heat from the front hull and wheels, making a front three-quarter view of this vehicle more confusing than the same view of other vehicles.
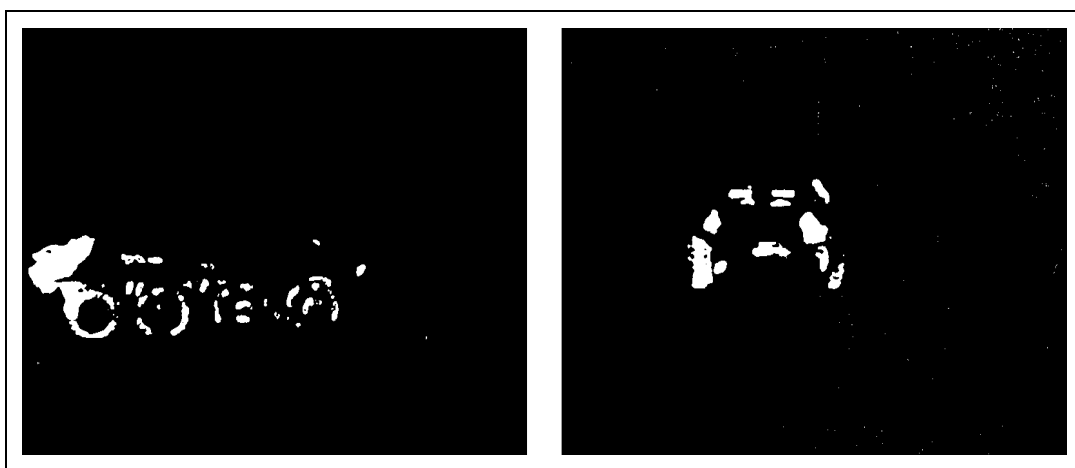

Figure I-8. BTR-60 armored personnel carrier.

BRDM-2 Reconnaissance Vehicle

Classification. Main characteristics of the BRDM-2 reconnaissance vehicle include—
- A rear engine and exhaust.
- A pattern of separate, wheel-sized red spots.
- An overall profile of a hull with (or without) turret.
- A gun tube that can be seen when the gun has recently fired.

Side-View Identification. BRDM-2 characteristics visible from both sides include —
- The vehicle's small overall size, indicated in part by the short distance between the two tires clearly visible on each side.
- A distinctive heat pattern formed by the rear mufflers and wheels. This pattern is clear even at long ranges. Left and right views are the same.
- The rear engine, which is clearly visible at long ranges.
- Two mufflers, one on each side of the top rear deck, which enlarge the hot spot created by the engine area.
- A choppy ride over rough terrain that is noticeable even at long ranges.

Front-View Identification. BRDM-2 characteristics visible from the front include —
- Two warm tires separated by a cool hull. The red spot of the differential may be visible between the front tires.
- A cool front hull, indicating a rear engine.

NOTE: Setting the brightness and contrast controls on high makes the entire front of this vehicle appear hot.

- The dark surfboard across the front of the hull can be seen.
- The tires are set closer together than the tracks of most armored vehicles.
- A greater height-to-width ratio than most armored vehicles, so that it appears narrower and taller.
- Over rough terrain, the vehicle tends to bounce more than armored vehicles.

Effects of Motion. The vehicle's direction of movement may indicate the location of its engine. Other characteristics that observers could see when the BRDM-2 reconnaissance vehicle moves include—
- A transport system that becomes warmer and more visible during movement.
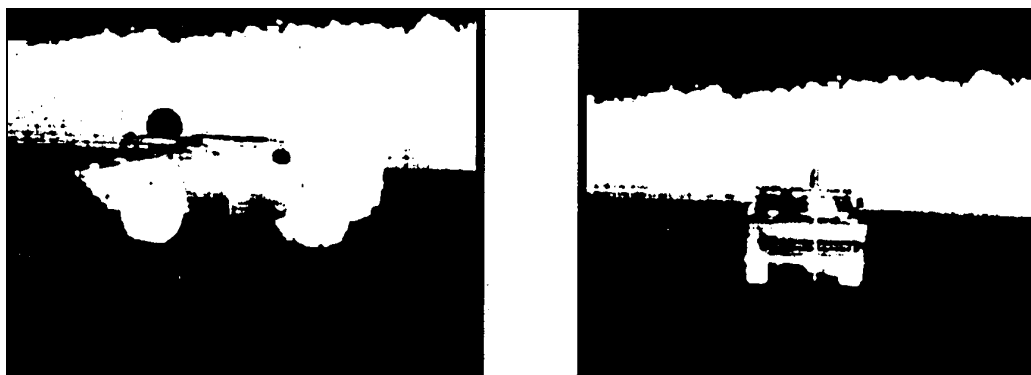- A sometimes visible exhaust plume whose direction indicates the direction of movement.

Figure I-9. BRDM-2 reconnaissance vehicle.